ELEMENTARY ESSAY ON MORTAR AND CEMENTS.

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(*Continued from p.* 239.)

44. Pozzolana is a porous, nearly non-calcareous, substance, which gives to mortar made of common white lime the property of hardening to an extraordinary degree and of setting in water; also of not settling, it is said, while hardening. It was discovered by the Romans, whether fortuitously or by experiment is unknown, in the vicinity of Puteoli, a town in the Bay of Baiæ, not far from Mount Vesuvius, and is considered a volcanic lava. It was used by that people in making their aquatic cements, not only for their villas in that town, some of which stood in the water, but wherever water-cement was necessary; and the essential requisites for which they found it to possess in the highest degree. Vitruvius terms it *pulvis puteolanus*; but Puteoli is now called Pozzuoli, and hence, by an easy transition, the material itself has acquired the name of pozzolana; it is a concretion, cellular and slightly cohesive in texture, and of a rusty colour. An analysis produced 56 per cent. of silica, 20 of iron, 19 of alumina, and 5 of lime. The only process required, preparatory to mixing it with the mortar, is pounding and sifting. There is a Roman pozzolana which is superior to the Neapolitan, as it will make into a proper cement with lime alone; while with the other a proportion of sand is necessary. The Neapolitan effervesces slightly with acid, which the Roman does not; and therefore it probably contains more lime, to the exclusion of a corresponding quantity of some other ingredient more virtual in a water cement. Pozzolana was long extensively used in this country in composing hydraulic mortars; but the necessity was completely obviated by the discovery of our Roman cement.

45. Tarras is a bluish basalt much resembling pozzolana in its structure, and is equal to it in its hydraulic properties. It is quarried at Andernach, in the neighbourhood of Cologne, on the Rhine, for the purpose of making mill-stones; and the fragments which accumulate in forming these are sent to Holland, where they are ground to powder, and used on a vast scale in composing the cements for the dykes and other water-buildings. The Dutch are said to have been the first who used it in this way; and they must have found it a most valuable acquisition. Large quantities were imported here and employed for similar purposes, until the discovery of the Roman cement happily rendered foreign aid in this important particular no longer indispensable. The Dutch and Germans call it *trass*; in this country it is commonly styled Dutch tarras. It has been stated to be inferior to the pozzolana, in regard that cements made with it do not set so firmly when exposed to the action of the air as they do under water; also that they are liable to decay, either so circumstanced or alternately wet and dry—being excellent only if always under water. But there is reason to suppose the specimens used in the instances upon which this opinion was founded, must have been impure, or in some other respect imperfect; for in Germany and the north of France, as well as in Holland, it is considered to be equal to the best Italian pozzolana, whether in a wet, damp, dry, or inclement situation; and the Dutch at least must, from their extensive experience, be well qualified to judge. Still, as there is, unavoidably, much opportunity for adulterating a commodity of this nature in the course of transmission, it is not improbable that in general, by the time it came to market in this country, it might hardly be fit to support the high reputation it obtained on the Continent. Another disadvantage attributed to it, is a troublesome growth from the joints, produced by a chemical action among the ingredients, and which sometimes projects so as to require being cut away.

46. Tarras may be mixed either with common or water limes, but the proportions that are adopted in the two cases are different. When common white lime is employed, equal parts of it and the tarras compose the mixture; the former being in the state of quick-lime ground. These should first be thoroughly mixed, then, with a very small quantity of water, beaten to the consistency of paste. When a hydraulic lime is used, two parts slaked in powder, one part tarras, and three parts sand, are the ingredients and their proportions: the latter is considerably the cheaper of the two, and is little if at all inferior to the other as a water cement.

47. Rowley Rag, a non-calcareous stone, the essential ingredients of which seem to be oxide of iron and burnt clay, is very similar and little if any thing inferior to tarras in the power of giving to mortar made of white lime the property of setting under water.

48. Arena is the name given to a fossil sand accidentally discovered by the proprietors of some mills situated on the river Isle, in the department of the Gironde, which gives to mortar made with common white lime not only great durability, but the quality of setting under water: it requires no preparation, but is only used instead of ordinary sand.

49. M. Vicat, a good authority on the subject of calcareous cements, especially on that part which relates to artificial hydraulic limes, and who established a manufactory at Paris for making the latter on a large scale, chiefly from lime and clay, states the proportions of clay to be added to one part of lime as varying so widely as from about $\frac{1}{10}$th to $\frac{1}{3}$th; the lesser quantity being given to such as are naturally hydraulic in the greater degree, and therefore already possessing a certain portion of clay. The due allowance to the best carbonate, however, he states at $\frac{1}{4}$th: when the larger proportion is incorporated with the lime, it does not slake, but still pulverizes easily and hardens readily under water. It has to be remembered, on this head, that all clays are not identical, and that the finest and softest are the most suitable.

50. There are several methods employed at the manufactory mentioned: one, the superior but more expensive, is formed by burning together slaked lime of a rich quality with its due proportion of clay. In another, which is also of a satisfactory character, chalk, or some other calcareous substance which can be bruised down with facility, is reduced to a paste with water, and being amalgamated with the clay as intimately as it is susceptible of, is then subjected to the calcination. By this mode an important saving is effected in the burning alone, although the hydraulic lime which it affords is in quality rather inferior; but the course usually adopted is to burn together four parts of very rich slaked lime, or seven parts of carbonate, with one of dry clay; the lime being, when this formula is followed, free in itself from the latter ingredient.

51. Artificial pozzolana is also manufactured in various ways at the establishment referred to: the best is composed by strewing pulverized clay, psammite, or aréne, in a layer of (as deduced from the French measure) rather better than one-third of an inch in thickness upon an iron plate, at a heat somewhat under forging temperature, and continually stirring it thereon with an iron rod, until the calcination is uniform throughout, which takes from five to twenty-five minutes, according to the material. The stiff brown clays, which do not contain lime, and which calcine to a brick red, are rather better than the white or pipe clays in which silica prevails, and that change to a light pink. The pozzolana obtained from the former, when mixed with an equal quantity of lime, sets hard in about three hours; a similar combination with the latter takes double the time to set and does not become so enduring. Those clays which are fine and soft to the touch, consisting chiefly of silica and alumina, and that contain the least carbonate of lime, but are more or less ferruginous, afford by the above method pozzolanas of excellent quality, which acquire in water the hardness of brick.

52. There is an artificial pozzolana, or rather water-lime, made by burning one part slaked lime with three parts clay for some hours at a red heat, and then covering it over in the kiln with sand or earth, and leaving it there to cool: after which it is kept in close casks till wanted.

53. Frost's Artificial Pozzolana (patented 3rd April, 1823) is carbonate of lime, calcined at a heat not higher than the temperature at which cast-iron softens, and cooled without the access of atmospheric air or moisture: this has the property of setting under water.

54. It is considered, and probably with good reason, that a very good and quick-setting water-lime may be made of five parts chalk and two parts common clay. Most clays contain a metallic oxide, which will give the hydraulic property to common limes. It is stated that a good hydraulic lime may be composed of pure lime-stone and one-sixth of clay, by the process specified in article 18, in reference to oyster-lime.

55. The ash mortar, celebrated under the name of Cendrée de Tournay in France, so highly esteemed as a water-cement and extensively used in the Low Countries, is procured from the kilns in the Scheldt district, the lime from which contains a considerable portion of ferruginous clay, and is burnt with pit-coal of a slaty description, abounding in argillaceous schist impregnated with iron. When the main part of the burnt lime has been withdrawn from the kiln, the ashes of the fuel are found to be mingled with a remnant of lime-dust, averaging in its proportion 25 per cent. This mixture, when equalized, is taken about a bushel at a time, and water thrown on it just enough to slake the lime: when the whole has been treated thus it is thrown for several weeks into a pit and is covered with moist earth; then on being removed, it is put into a wooden vat, or trough, and beaten with an iron pestle until it becomes of a pasty consistency; after which it is spread out for a day or two in the shade, and is then again beaten up. These modes of treatment are continued alternately until the mortar acquires a degree of stiffness just proper for use. It adheres firmly with either masonry or brickwork, quickly forming a very compact mass, and in the course of 24 hours indurates like stone: it may be subjected to water almost instantly, and will endure the action of the most turbulent streams.

56. In London there is a blue mortar made of Dorking lime and cinders, which it is thought might be rendered, in quality, nearly equal to the Cendrée de Tournay, by bestowing on it similar careful preparation: it is used about work much exposed to weather. A mortar, composed of two parts of newly-slaked lime and three of wood-ashes, is said to be, for withstanding the effects of alternate dryness and moisture, superior to tarras mortar, although under water very inferior to it: it is best when kept for some time, and frequently well-beaten before used. There is an African maltha, or stucco, of some celebrity, which is composed by mixing three parts sifted lime-powder, two parts wood-ashes, and one part sand, with a little water; and after beating it up, adding a little oil and again beating the composition: this is repeated alternately for three or four days, until the composition is of the consistency proper for use: it is applied in the usual way, and shortly acquires the hardness of stone.

57. Forge-scales and common lime, in equal quantities, make a water-cement that is very good for small works; the former should be pounded, and the latter, in a state of hydrate, in fine powder. Forge-ashes, also, with lime, make a very useful cement for securing the joints of buildings against the weather, and for similar purposes, although not capable of resisting the continual action of water. Mortar composed of iron scales two parts, argillaceous lime two parts, and sand one part, or an equal portion of each, if pure carbonate of lime be used, is said to be quite equal to tarras mortar; 3½ lbs. of sulphate of iron, incorporated with mortar, composed of one bushel of lime, and half a bushel of fine gravel sand, is said to render it equal to Roman cement. Plaster of Paris, mixed with iron-rust in the proportion of one-tenth, affords a water cement which immediately sets very hard; plaster and iron-filings also make a good cement. Oxide of iron, in almost any form, especially when not completely oxidized, not only enhances the peculiar property of mortars made with the brown and yellow limes, but gives tenacity and the property of hardening under water to those made of the common white kinds. Grey oxidized forge-scales are said to be, when pulverized and sifted, equal to pozzolana.

58. Common mortar, composed of lime and sand, and mortar in which there is burnt clay, are said to be much enhanced by the addition of boiled potatoes. The incorporating of vegetable matter certainly seems opposed to the orthodoxy of mortar-making; but it must be admitted that this objection is met, in a measure,

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